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Transport Membrane Condenser for Water and Energy Recovery from Power Plant Flue Gas

NETL project kickoff meeting
Project #: DE-NT0005350

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Gas Technology Institute

> Main Facility:

18-Acre Campus
Near Chicago

- Over 200,000 ft^2 of laboratory space
- 28 specialized laboratories and facilities

> Staff of 250

- 70% are scientists and engineers
- 45% with advanced degrees

> Over 1,000 patents
> Nearly 500 products commercialized

Addressing Key Issues for the Natural Gas Industry

> Contract Research
> Program Management
> Technical Services
> Education and Training

Energy & Environmental Technology Center

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Background for Transport Membrane Condenser (TMC) Technology

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High Efficiency Goal for Super Boiler

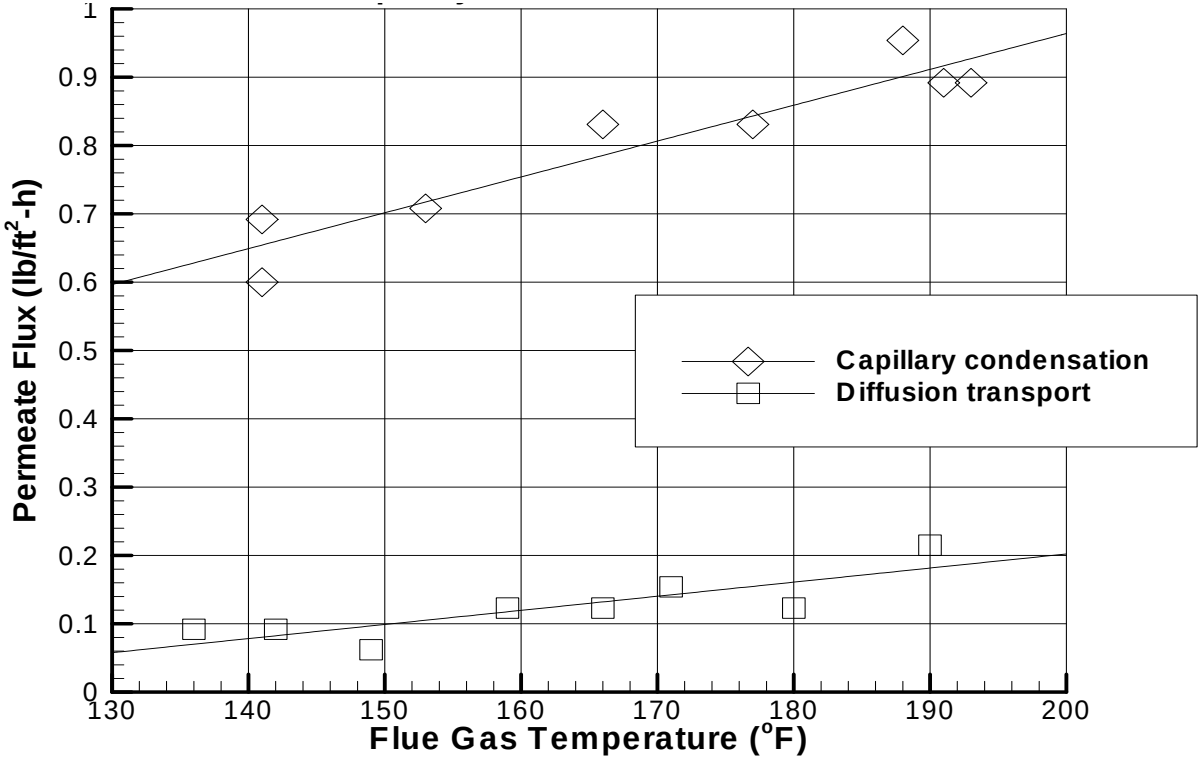
- Objectives of Super Boiler program:
  94% thermal efficiency
- Current gas- fired boiler efficiency status:
  75-85% thermal efficiency, 68% of stack heat loss is latent heat
- TMC, a device for recovering latent heat of water vapor from flue gas, is the key component for the Super Boiler to achieve its efficiency goal. Two patents were awarded to GTI on TMC-based heat recovery.

Water Vapor Membrane Separation Study at GTI

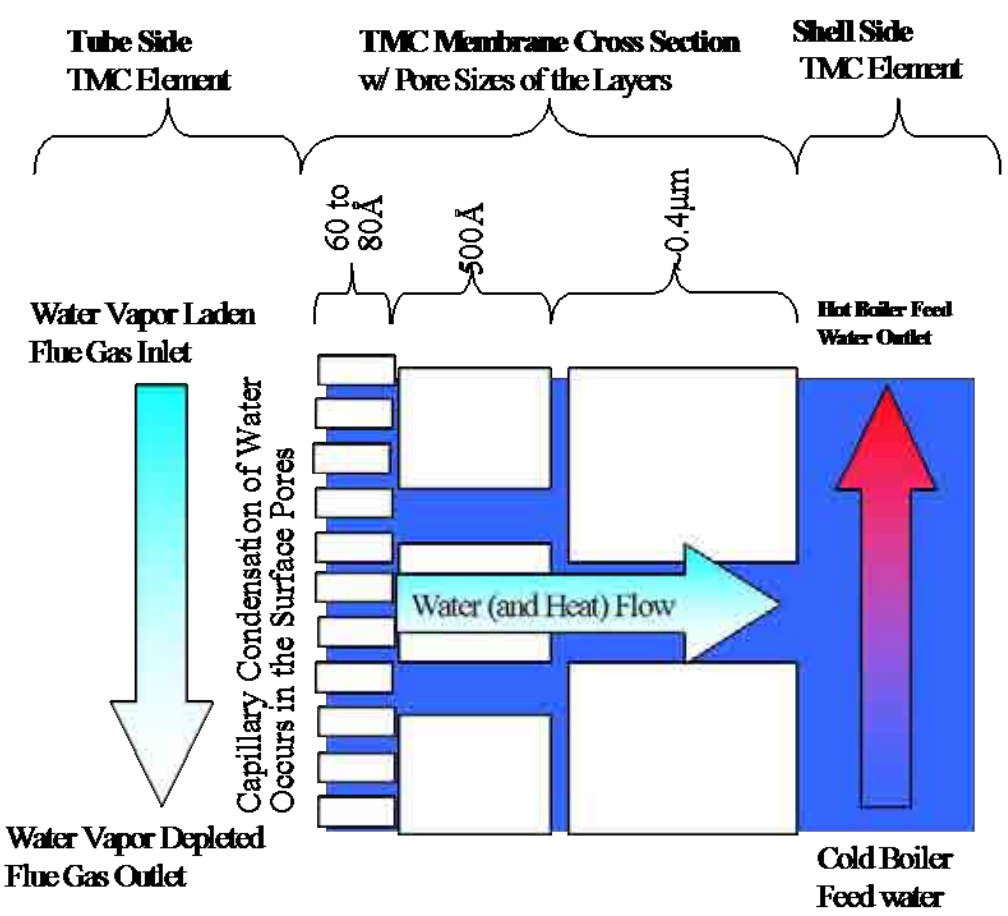
1. Porous and non-porous membranes
2. Porous Membrane Vapor Separation Modes:
   - Molecular Sieving
   - Knudsen diffusion
   - Surface diffusion, and
   - Capillary condensation
3. Working mode of porous membrane is critical for water vapor transportation.

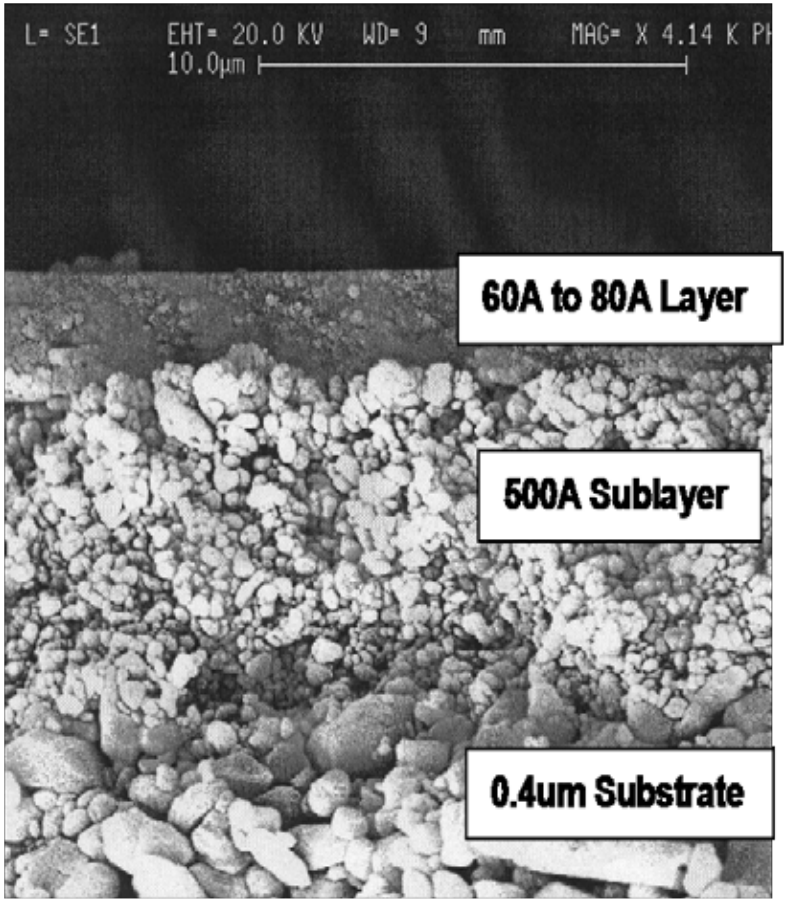
   High permeate flux and high separation ratio could only be achieved in a capillary condensation mode.

Capillary Condensation for Water Vapor Separation Study at GTI

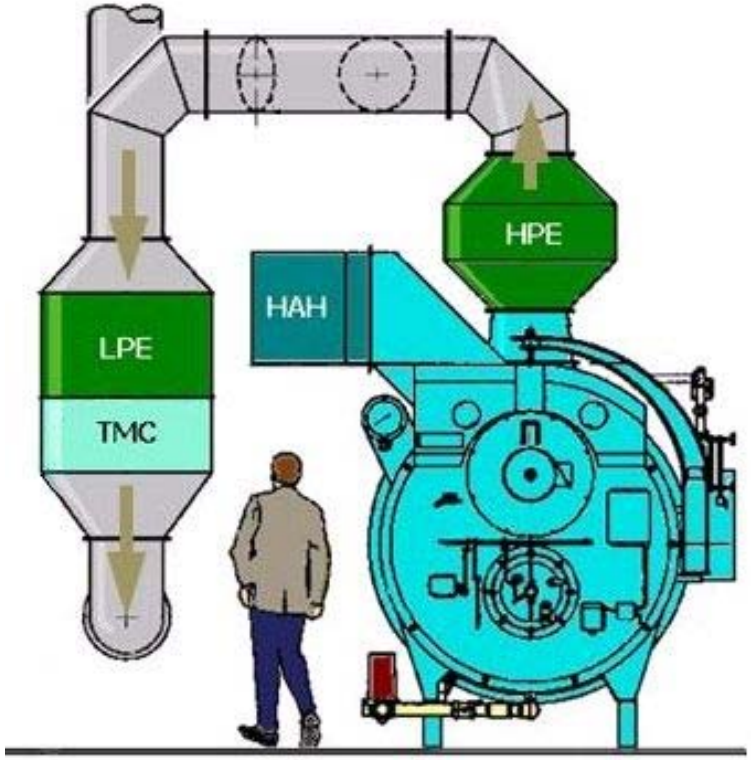


TMC Concept and Nanoporous Ceramic Membrane

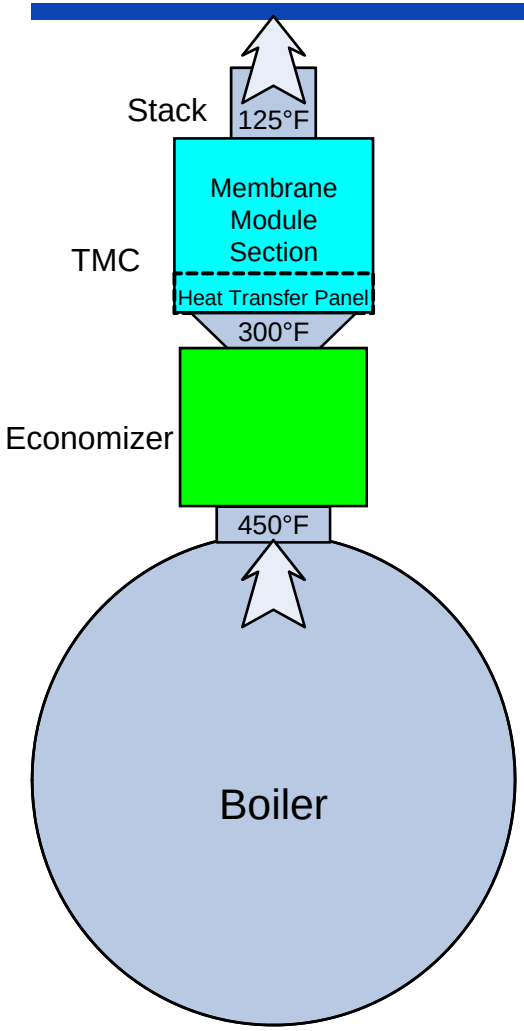




First Generation TMC Heat Recovery Field Demonstration for a 300HP Boiler (12MMBtu/hr)



Second Generation TMC Heat Recovery In Testing for a 200HP Boiler (8MMBtu/hr)



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TMC Potential Application for Water Vapor Recovery from Coal Flue gases

Advantages:

1. Higher moisture content in coal flue gas:
   - With Wet FGD, flue dew point 160 to 180 F
   - With Dry FGD, flue dew point 130 to 140 F
   - Compared with natural gas boiler flue gas: 130 to 136 F

2. More favorable cooling conditions for TMC:
   - Steam condensate can be one cooling water source, typically at 90 to 115 F.
   - Cooling water flow rate is typically at 25 times of the boiler feed water flow rate, from 50 to 100 F.
   - Compare with industrial boiler which has only 10 to 50% of feed water flow rate.

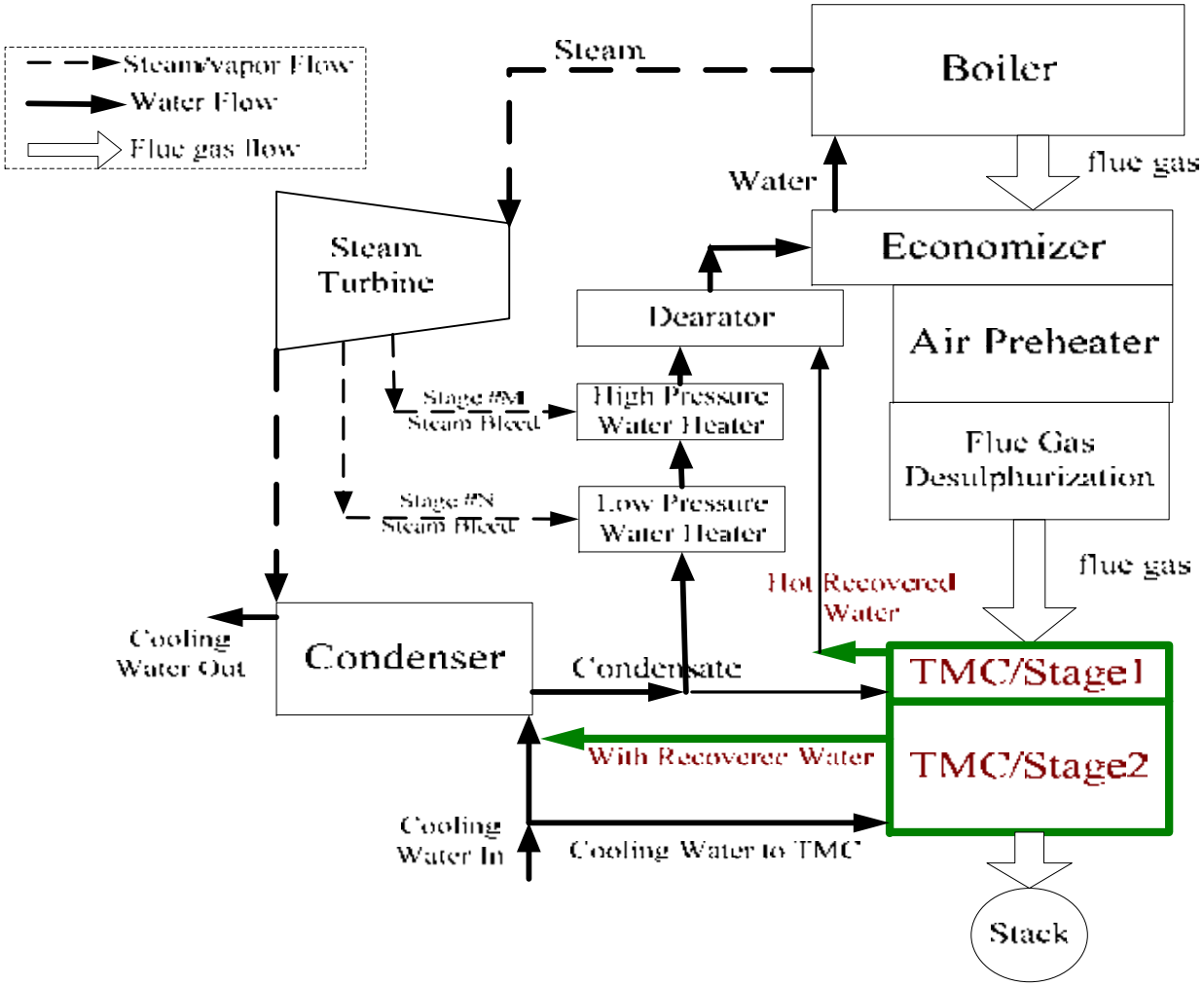
TMC Potential Application for Water Vapor Recovery from Coal Flue gases

Disadvantages:

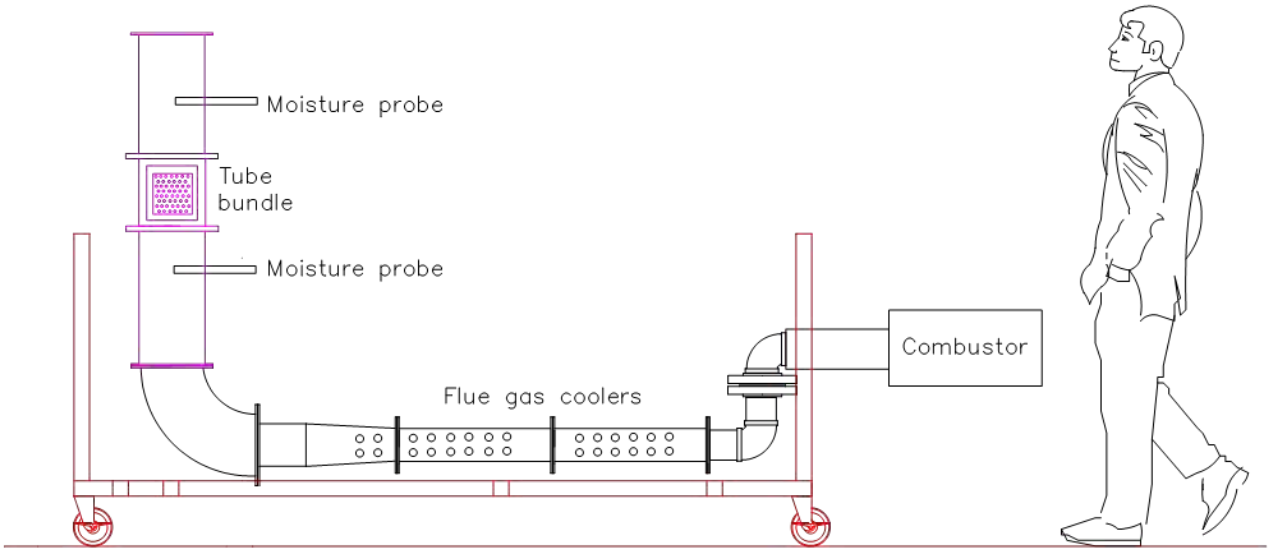
More complicated components in coal flue gas:

- SO_2, heavy metals, particulate matter, etc.
- Compare with relatively “clean” natural gas-based flue gas

Power Plant Flue Gas Water Recovery with a Two-Stage TMC



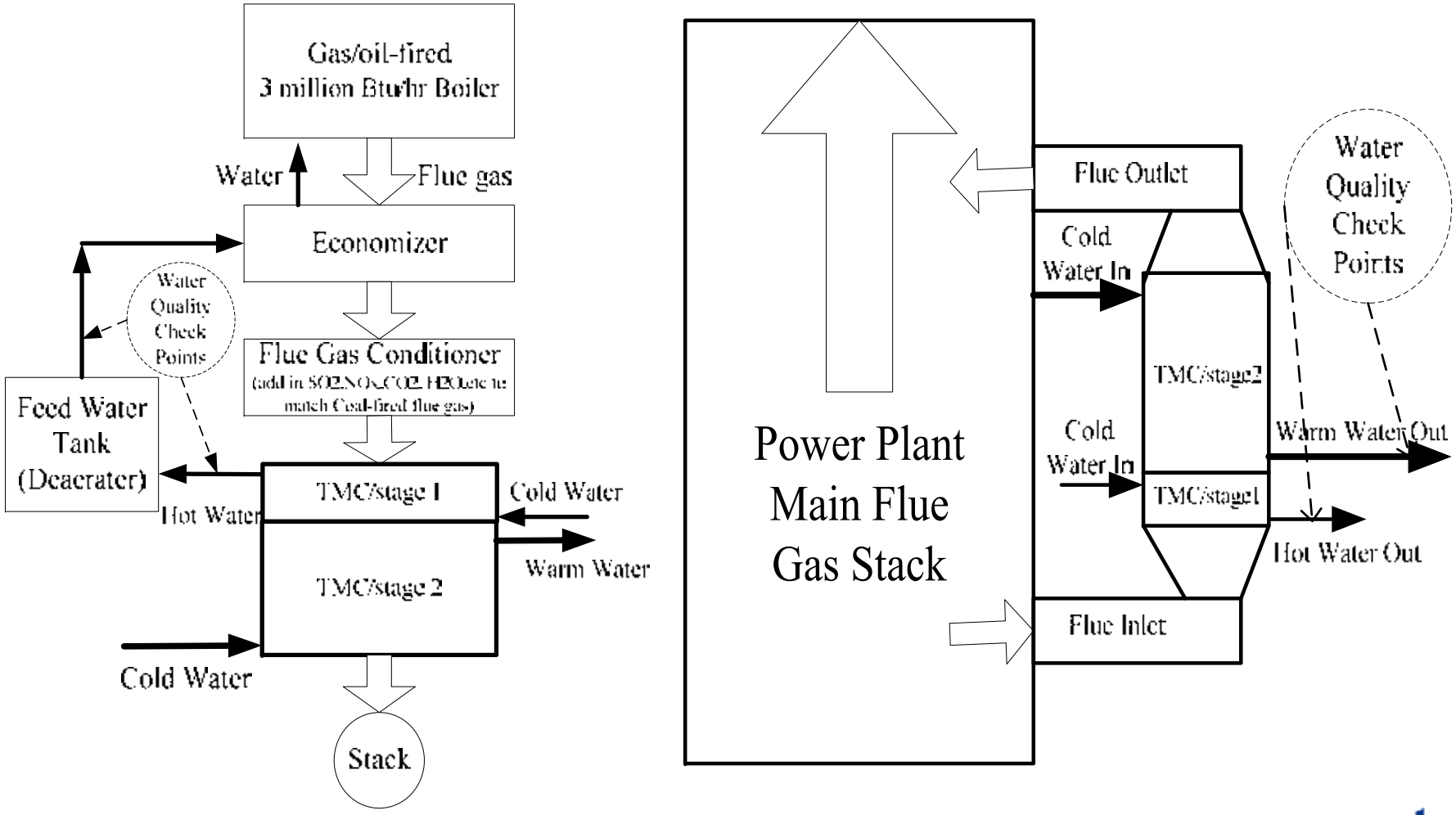
Lab test setup for membrane module performance tests



Membrane water/heat transfer study:

- Select the optimized membranes for the two stages
- Membrane contamination condition study

Pilot-Scale TMC Test Setups at GTI (left) and at a Power Plant (right)



Scale-up and Technology Transfer Study

1. Scale-up Design Investigation:
   - Based on the pilot-scale test data, develop a preliminary design for an appropriate size power generation unit to employ this technology, and integrate the recovered water to the boiler water management system.
2. Technology Transfer and Commercialization Plan.
   - Identify potential manufacturers and customers for field demonstration, and develop a manufacturing plan to meet the needs of utility customers.

Questions?

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